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## THE NEXT STEP IN APPLIED SCIENCE

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IT was long ago that Plato taught that science should not be applied to the mechanical and industrial arts, but to education, social culture and social health. And a century and a half have passed since Rousseau's celebrated essay, in which he tried to show that the arts and sciences had done nothing to advance human happiness. From our modern view-point these were the pathetic mistakes of great men, so richly, as we think, has science vindicated itself in its practical applications.

Consequently, when the term "applied science" came into use not many years ago, it was heralded with great joy, for we were weary of Plato's theoretical ideas about justice and truth, and skeptical about his plan for racial culture, and we longed for something practical and immediate. We welcomed, therefore, the direct application of science to our every-day needs, and when, in response to this demand, science began to shower its practical applications upon us, it seemed to many that a kind of golden age had come at last. It revealed to us the only god worthy of our worship—the god of social welfare, social welfare being generally interpreted to mean the comfort, happiness and convenience of the present generation.

While we may not question the almost unlimited possibilities in the application of science to social welfare, nevertheless, we may raise the question whether science has thus far been applied to the right things. The war has shaken the foundations of so many of our accepted opinions that even our faith in applied science may receive a rude jolt. Since we are now entering upon a period of reconstruction, which many believe will involve not only our social and political ideals, but also our ethical and religious beliefs, it is legitimate enough to ask whether applied science has vindicated itself by its results and what place it is to occupy in the coming order.

Our first thought is that applied science has been not only a stupendous success, but perhaps the crowning achievement of the human mind. The story of its triumphs is known by heart to every school girl. Applied science has made the world over, making it a decent and healthful place to live in. We

press a button and our houses are filled with light. Scientific heating, ventilation, drainage and sanitation have made our homes places of cheer, comfort and health. The motor car, smooth, noiseless and swift, saves our time and our nerves. Time-savers too are the typewriter, the dictograph, the multigraph and the adding machine. Communication is facilitated by the wireless telegraph, the telephone and the aerial mail.

It is needless to go through the familiar list. Lest, however, it should be thought that applied science has given us only comforts, conveniences and time-saving devices, we are reminded of its triumphs in the conquest of disease, in public sanitation, in surgery, dentistry and preventive medicine, and in the application of chemistry to agriculture. And, most manifest of all, are the countless applications of science to the industrial and mechanical arts, increasing the efficiency of labor, thereby shortening the hours of the laborer, as well as ministering to his comfort and health. Certainly applied science has made the world a tidy place to live in and contributed an untold sum to human happiness and welfare. Surely, had Rousseau lived in the twentieth century he would never have written, even for the sake of a brilliant paradox, an essay questioning the value of the arts and sciences to civilization.

We may not, indeed, question the potential value of applied science, nor even its actual value in countless directions. What we may question is whether there has been a mistaken conception of the general end to which science should be applied in respect to real social welfare. To what extent has science, as it has actually been applied, contributed to human good?

First, applied science has surrounded us with comforts, conveniences and luxuries of every kind. But just what will be the effect upon a race of men, disciplined through a hundred thousand years of hardship, of this sudden introduction to comfort? This question puts the whole subject of applied science in a new light. Perhaps we have been applying science to the wrong ends. Possibly science should never have been applied to making man comfortable, but to making him perfect. It may be that there is great danger in comfort. The biologist holds it in grave suspicion. Degeneracy is its sequel. It was through struggle and warfare and the overcoming of obstacles that man fought his way up to manhood. With infinite effort he gained an upright position the better to strike down his enemies. Strong legs and stout arms were the correlates of his growing brain, the latter itself finding its necessary support in a powerful heart and vigorous digestive system. There is an

especially intimate connection and interdependence between the brain and the muscular system, making the latter indispensable to the proper functioning of the former. Now, applied science has shown us how machinery may take the place of the stout arms and the motor car may be a substitute for the strong legs, while science itself and the applications themselves draw more and more heavily upon the powers of the brain. The harder the brain has to work in the pursuit of science and the mechanic arts, the more it stands in need of the physiological support of the muscular, digestive and circulatory systems. But, for maintaining the health and integrity of these, our present manner of living is not well adapted.

"Oh, well," it is replied, "there are no signs of physical degeneration yet. Look at our armies. Finer physical specimens never marched out to meet an enemy." This is true and we may add—braver ones never went to war and they were 100 per cent. efficient. Yes, but they were picked men, the very flower of a vast nation. They were from the upper tenth physically. They were the young males. They were the 65 per cent. of the young males not rejected by the examining boards. The germ-plasm of the best of our race could not suffer deterioration in the short time of the "comfort" régime. But upon biological grounds we must believe that the disastrous consequences of such a régime upon society as a whole may be serious in the highest degree.

Another of the most brilliant triumphs of applied science is seen in our countless and wonderful labor-saving devices. The effect of these is either to decrease the amount of labor or by increasing its efficiency to increase the products of labor. But we simply *assume* that increased wealth and decreased labor are human blessings, although both may be quite the opposite. It has been seriously questioned whether civilized man has gained enough moral and physical poise to be trusted with the immense wealth which applied science, working upon our suddenly acquired store of coal and iron, has supplied. The war did not count the poverty of the nations among its causes, and if greed is the root of most modern evils, it has not been shown that increasing wealth and increasing comforts have lessened it.

Again, just why has it been assumed that *labor-saving* devices are a human benefit? Work, and indeed physical work, is a blessing, not a curse. During the past history of man, which we may reckon in hundreds of thousands of years, Nature has said to him, "You must work or die." Labor-saving

devices, discovered at a recent moment in this vast history, may enable one half the members of society to live without work and reduce the working hours of the other half, with results most pleasing for the moment, but perhaps most disastrous in the end.

Is it not conceivable that applied science might be used not only to reduce the hours of labor of those who are now crushed with *excessive* labor, but to devise means of preventing the disastrous biological consequences which must follow the cessation from healthful labor among a considerable portion of society?

And then there are the time-saving devices. It is no doubt because of the temper of the day that so few of us have ever questioned their intrinsic value. But with all these time-saving devices it is not quite apparent that we have any more time than formerly. Sometimes it seems as if we have less. Leibniz lived before the time of typewriters and dictographs, yet he is said to have had a thousand correspondents and in addition to his duties as court librarian, diplomatist and historian, he found time to discover and perfect the differential calculus and to write great works on philosophy. In any case the value of time-saving devices will depend upon the use of the time that is saved. As it is, it appears to be used very largely for carrying on more business, to make more money, to buy or invent more time-saving devices. Even if there results a certain amount of leisure, much depends upon the manner in which the leisure is spent. If it is spent in sitting quiescent in a darkened moving-picture room, gazing spell-bound at a tawdry drama, the gain is not great.

In all our plans for improved economic and social conditions, it is uniformly taken for granted that leisure, resulting from a shortened working day or from time-saving devices, will be an unmixed good. Leisure in itself is not good; it may be dangerous. There have indeed been epochs in history when men, released from labor by wealth or otherwise, have turned their thoughts to beautifying their environment and surrounding themselves with works of art. At such times, too, poetry, music and the worthy drama have flourished. Is it quite certain that we are now living at a time when mankind can be trusted with leisure?

To all such arguments as the above it will be replied that modern science has nevertheless made the world a decent and comfortable place to live in and that there has never been so much happiness in the world as at present. But, for the last four years Europe has not been a decent nor comfortable place

to live in nor has there been general happiness, although Germany excelled in its development of science and in the application of science to the mechanic arts. A good civilization must insure some degree of stability.

In this connection we are reminded that there is one field in which science has distinguished itself beyond all others, and that is in the art of war. To the exquisite perfecting of this art every science has been called upon to contribute its very best and latest results—mathematics, engineering, physics, chemistry, metallurgy, mechanics, optics, radio-activity, electro-dynamics, aeronautics, economics, zoology, psychology and many others. An immeasurable weight of the best and keenest thought of the world has been expended in the application of science to the paraphernalia of war, resulting in an amazing progress in the development of this art to the highest conceivable degree of perfection.

If in defence of this kind of application of science one should say that by this art civilization has been saved, it would only be because by this art it was threatened. Given an unscrupulous nation dreaming of world dominion and harassed by the need of commercial and industrial expansion, that nation would never have dared to venture on this ambitious project, had it not been for the fact that she found herself in possession of such an arsenal of cunning devices as to make success apparently certain—submarines and superdreadnaughts, mines and torpedoes, airplanes and monster dirigibles, titanic cannon and marvelous machine guns, secret formulæ for super-explosives, poison gases and liquid fires—these are some of the implements of war which applied science had put into her hands.

The results, whether one choose to regard them in terms of sorrowing homes, of outraged and degraded morals, of the loss of the best young blood of all the nations, of enslaving national debts, of the disorganization and ruin of world commerce and industries, or of the destruction of art treasures, are equally appalling.

If, as many believe, one of the prominent causes of the war was the urgent need which Germany felt for commercial and industrial expansion, we seem in this very fact to have an indictment of the mechanic and industrial arts, when viewed in the light of the leading motive in the social order. Nowhere else in the world had science been applied so extensively and successfully to the satisfaction of human wants as in that country. Yet these wants were not satisfied and Germany had to

fall back on the age-old method of the exploitation of other nations. But we are evidently coming to the time when this method will not work. Perhaps it may be a long time before it will again be tried. Each nation must satisfy its own wants by peaceful means, and thus the question faces us whether any possible development of the mechanical and industrial arts, upon which we rely so fondly, will satisfy the desires of man.

In former times wars acted to purify racial stocks by eliminating weak races. Modern wars have precisely the opposite effect, owing to the fact that a modern war kills or disables the best young men of all the warring nations, and so, by destroying the most valuable germ-plasm of the race, causes irreparable damage to society. Applied science has devised every conceivable means to make the destruction complete. Would it not be well, therefore, in the years to come for science to apply itself directly to the problem of preventing wars? It is idle to say that they can not be prevented or that science has nothing to do with this problem. It lies distinctly within the field of such sciences as biology, psychology, sociology and education. For applied psychology it offers a most alluring field. It may be an immense problem but the possibilities of science are immense.

At present we are depending too largely upon political readjustments to prevent war. The strong arm of international law is to be invoked to repress any aspiring belligerent nation. This is no doubt well, and may put a check upon wars between nations, but the menace of civil war will be ever present. A great nation may be torn asunder by a dispute about slave labor or a quarrel over religious creeds; mere rivalries between families, clans and classes may cause the streets of great and beautiful cities to run with blood, or a whole nation may simply lapse into civil war as a result of the disintegration of outworn political institutions. Any of these causes seems less promising for war than the conflict of labor and capital which is facing us.

We have thus in the preventing of war a real problem for applied science, especially for applied psychology. Let us, by all means, make over our laws and our international relations to the end of preserving order, but let us direct our main endeavors to making over our men and citizens so that they will have sense enough to settle all their disputes and controversies in some more rational way than by blowing out each other's brains with high explosives or by dropping bombs from aeroplanes to destroy buildings that they have erected with infinite

labor. Education will be efficient here, but it is an especially attractive field for applied psychology. The source of war is in the human brain, where the instincts of combat lie deeply imbedded, sanctioned through the warfare of thousands of years of human history. To eradicate these instincts may be difficult. To substitute some other form of expression for them may be possible. At any rate it would be worth while to turn in these directions a fraction of the brain power which has been expended in the invention and circumvention of the submarine boat or in the transmission of messages by means of the ether.

But it may be said, if applied science has not contributed as much to human welfare, as first appears, in the field of mechanic arts, nevertheless there are other fields in which its contributions are unquestioned, notably in hygiene, sanitation and agriculture.

The deep obligation which the world owes to applied science for its work in social and domestic hygiene, in applied bacteriology, in surgery, dentistry and preventive medicine, is appreciated by everybody. But the question arises whether even here science has been applied in just the right direction.

Let us take dentistry as a convenient illustration. This highly perfected modern art has given us beauty and symmetry of the teeth, replacing the deformities which formerly were so unsightly, particularly among older people. But obviously we have here not a remedial art, but a patching-up process. Crowns and bridges and artificial substitutes, themselves often the sources of infection disturbing the health of the whole body, have replaced the sound white teeth which nature should supply. At one time in our racial history sound teeth were necessary to the survival of an individual. They are scarcely so at present, for with artificial teeth and soft prepared foods one may get along very well and one's children may inherit the inner defects. This process can not go on forever. Under the old régime, before the rise of modern dentistry, there was at least a force, powerful if not always effective, working to the end of sound natural teeth. The dentist's art has to a large extent displaced this force. Is it too much to conceive of a new dentistry which shall have for its object not to make people look better, but to make them really better? If it is replied that this is precisely what the most recent dental art aims at in its teaching of oral hygiene, it is still true that this work relates largely, if not wholly, to the individual, for such acquired characters are not inherited, so that dental de-

generation may be going on unchecked, as has been shown to be the case in England. The problem may be a difficult one, but not necessarily beyond the power of applied science.

Then there is the conspicuous instance of the apparent triumphs of applied science in the conquest of modern diseases, particularly those of bacterial origin. Science has discovered, for instance, the cause and cure of tuberculosis. What greater boon to humanity could there be than this discovery, with its keen diagnostic technique, its therapeutic methods and its fresh air cult? It would appear, however, from no less an authority than Professor Karl Pearson that the death rate from tuberculosis has been decreasing as far back as our records go and that since the introduction of the new methods of treating this disease, which date from about 1890, the decrease in the death rate has been less rapid than before. Neither is this startling situation due to an increase in urban or factory life, as is shown by the recent rapid ravages of this disease in rural districts. Even though the accuracy of Professor Pearson's statement may be questioned and even though it be true that many diseases are now diagnosed as tuberculosis which were formerly classed under other names, nevertheless it is becoming clear that this branch of applied science has not been so sweepingly successful as was at first hoped, and that it may be well to supplement nature in her efforts to produce a degree of immunity to this disease by strengthening constitutional resistance. Methods of accomplishing this end are well understood now, since the Mendelian laws of heredity became known. It is only necessary to *apply* this branch of science.

In respect to general social hygiene, the benefits conferred by applied science seem certainly at first sight to be unimpeachable. One thinks immediately of our clean houses and our clean cities, of our comparative freedom from the scourges of smallpox, cholera, typhus and malaria, which in former times decimated the people. One thinks, too, of the marvelous triumphs of sanitation in the Panama Canal Zone and in our colossal national army, army camps and cantonments, both at home and abroad. One thinks of our efficient and sanitary hospital service, of our wonderful restorative surgery, our orthopedic art, and our discovery and application of anesthetics to the relief of pain.

The benefits, at least to the present generation, of this social hygiene are so patent that few of us have stopped to question whether it is strictly speaking social hygiene at all, or, if it should be so called, whether it is the highest kind of

social hygiene. Social hygiene must have as its end a really healthy people, not a weakened race which at every turn must be corrected and protected by artificial means. Our method of combating epidemic diseases has had for its two main objects the protection of the individual from infective agencies and the discovery of neutralizing antitoxins. Little attention, one might say almost no attention, has been given to making the individual constitutionally resistant to these agencies. It is perhaps a losing game to try to protect the human race from toxic and infective agencies. Brilliant temporary results may be gained, but a new swarm of microscopic enemies will ever be on the scene to take advantage of their weakened victims. So while we gain control over smallpox and typhus by constantly repeated devices, epidemics of infantile paralysis, influenza and pneumonia cause us to renew our Sisyphean labors.

In the meantime, while we are making headway against typhus and malaria and perhaps against tuberculosis, we hear of the increase of cancer, venereal diseases, diseases of degeneration, diseases affecting the heart and arteries, diseases of the digestive and eliminative organs and of mental diseases and diseases of the nervous system. We are perplexed to hear that the percentage of mothers who are willing or able to nurse their own babies becomes yearly smaller. While applied science has shown us how to quadruple our wealth and increase indefinitely the fertility of our soil, it has shown us how to decrease the fertility of our women, and since the new art is becoming fashionable among our best people but not among our worst, we have the unhappy prospect of actual racial deterioration, already evinced by the increase of poverty in a world teeming with wealth and by an increase of feeble-mindedness, insanity and crime. When bank robberies flourish during a time of unlimited prosperity, at a time when almost any person can get work at almost any wages, it would appear that the trouble is not in our social institutions but in the convolutions of our brains.

Nature seems to have discovered many ages ago that the way to make any race of animals or men strong and hardy was not to shield them from their enemies, but to give them power of resistance against their enemies.

Is it too much to hope that in the period of reconstruction to which we are looking forward, science may be applied less to shielding us from all manner of dangers and evils and more to making us strong to overcome evils; less to the production of comforts and conveniences and more to the encourage-

ment of hardihood and vigor; less to the increase of efficiency and the piling up of wealth and more to the production of racial health and stability?

Science has always been applied, and successfully, to our immediate needs as they were understood. The immediate needs of our present time are not more wealth and more luxury and more efficiency, but more racial and constitutional power of resistance to physical disease and more individual power of resistance to every alluring immediate joy which threatens the permanent welfare of society. We need steadiness and self-control and the limitation of our desires. The centrifugal motive which has ruled the world for the last fifty years has gone far enough. The world is small and there are limits to the expansive opportunities both of the nation and the individual.

Germany complained before the war that she was bound by a surrounding iron ring. To be bound by an iron ring is irksome. She longed for expansion. Hereafter expansive nations will understand that they can expand upward or downward at will but not sidewise, because other peoples also have rights. But individuals will have to learn the same lesson of limitation and self-government, and classes within a nation will have to learn it, else international troubles and even civil wars may take the place of collisions between states.

This, of course, will be applied science in a broad sense, applied psychology, applied ethics, applied sociology, applied biology, applied philosophy—and the growing interest in these sciences is one of the fine things of the present time.

Specific directions in which science may be applied to human welfare are found in conservation and education, and in eugenic control. Science has already been applied to the conservation of our soils and forests. It must be more widely applied to the conservation of all our physical and mental resources and particularly to the conservation of racial values. It may be feared, however, that both these forms of conservation imply a degree of self-control and limitation of desires which is foreign to the spirit of this individualistic age.

In the reconstruction era which we are approaching, the danger is that in the spirit of the times we shall attempt to solve the profound social problems which confront us mainly in two ways, first, by the further development of the mechanical and industrial arts, and second, by the manipulation of political institutions. We shall try, by means of new labor-saving and time-saving devices and new mechanical appli-

ances, to multiply still further the wealth of the world. We shall try, by means of some form of socialism or syndicalism, to provide that this wealth be more equitably distributed than it is at present. We shall try by the further extension of democracy and by equal votes for women to provide that justice prevail more widely than now. We shall try by sumptuary laws and by a league of nations to see that drunkenness and child labor are prohibited and wars between nations abolished. And, then, when all these things are accomplished, we shall look for peace, happiness and plenty to reign on earth. Just here is the source of possible defeat. It is not that socialism and votes for women and extension of democracy and a league of nations are not proposals of the very highest value. It is only that we shall depend too much upon these things for the salvation of society, and shall insist too little upon such other factors as conservation, self-control and the limitation of desires.

A good society will depend more upon the materials of which it is composed than on the forms in which these materials are put together. It does not take many laws or many social institutions to make a good society out of good men but it is doubtful whether laws and political and social institutions can make a good society out of evil men, and if this saying seems as trite as it is true, we must remember that the evil in men has a physiological basis and that its cure is not wholly beyond the possibilities of applied science. Suppose, for instance, that this problem were attacked with the same magnificent confidence as that displayed in the giant task of linking two oceans at Panama, or navigating the air, it would yield to the limitless power of the human intellect.